

(Date signed)

OPEN AIR OPTICAL CHANNEL

FIELD OF THE INVENTION

[0001] The field of the invention relates to circuit boards generally, and more particularly, to apparatus and methods for communicating data over an open space between circuit boards.

BACKGROUND OF THE INVENTION

[0002] Computers and other electrical devices operate using printed circuit boards (PCB's), thin substrates on which chips or other electronic components are mounted. In the context of personal computers (PC's), some circuit boards, called backplanes, contain sockets for expansion cards, special circuit boards that, when inserted into the backplane, add new capabilities to the computer.

[0003] Backplanes are often described as active or passive. Active backplanes contain logical circuitry that performs computing functions. On the other hand, passive backplanes contain almost no computing circuitry. Most backplanes used in personal computers are active, but there has been a recent move toward passive backplanes.

[0004] In a passive backplane system, active components such as the CPU are inserted on an additional card, making it easier to upgrade and to repair faulty components. Whether a backplane is active or passive, a PCB inserted into an expansion slot can communicate with another PCB inserted in the backplane via the PCB's edge connector, a tabbed edge of the PCB containing a plurality of parallel traces. When inserted into an expansion slot, the traces on the edge connector connect with a corresponding plurality of traces inside the expansion slot. These internal traces connect through the backplane to other expansion slots and to other components on the backplane

[0014] Figure 6 illustrates a sectional view of a stack of circuit boards having multiple open air communications channels between them according to another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] Various embodiments of apparatus and various embodiments of methods to communicate between a first circuit board and a second circuit board using one or more open air communications channels are disclosed. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one of ordinary skill in the art that these specific details need not be used to practice the present invention. In other circumstances, well-known structures, materials, or processes have not been shown or described in detail in order not to unnecessarily obscure the present invention.

[0016] Referring now to Figure 2, two circuit boards (201, 202) are shown, according to one embodiment of the invention, having multiple open air communications channels (230, 240) between them. Each circuit board (201, 202) includes one or more light transmitters (210, 220) and one or more corresponding light receivers (212, 222). In one embodiment, light receivers 212 and 222 are uniquely tuned to the transmitting frequencies of corresponding light transmitters 210 and 220. As used herein, the term "light" includes visible and invisible light. For example, a light transmitter may transmit data signals using visible or invisible light.

[0017] In one embodiment, Vertical Cavity Surface Emitting Lasers (VCSELs) are used as light transmitters (210, 220). Because it is desirable to improve the signal integrity of each communication channel (230, 240) by maximizing each channel's signal-to-noise ratio (SNR), the placement of the VCSELs needs to have proper spacing so that the same color VCSEL does not interfere with an unintended neighboring light receiver of the same

more light transmitters and light receivers. In any embodiment, the light receivers and light transmitters may be placed anywhere within the X-Y plane of the circuit board to which they are attached, including the planar surface of the circuit board's tabbed edge connector. Additionally, one or more light transmitters and/or light receivers may be positioned within the thickness of an edge or edges of the circuit board substrate. Edge mounting light receivers and/or light transmitters on circuit board 301 or 302 expands the number of communication channels available. For example, whereas a circuit board having light receivers and light transmitters coupled with both of its planar surfaces can communicate only with two other adjacent boards, a circuit board having edge mounted light receivers and light transmitters can communicate with at least four other circuit boards positioned around its four edges.

[0021] Light transmitters and/or light receivers may be attached to or coupled with a circuit board using any one of a number of suitable attachment or coupling methods well known in the art, such as, for example, by soldering, by an adhesive, or by a physical connection, such as a bracket. In one embodiment, the light receivers and/or light transmitters may be flush mounted within apertures in the circuit board. In another embodiment, brackets 321 may be used to attach the light transmitters and/or light receivers to the circuit board.

[0022] Optical fiber may be used to link light transmitters and/or light receivers to a circuit board where it is desirable to connect them to various components on the circuit board, such as other light transmitters and/or light receivers. For example, in Figure 3, an optical fiber (not shown) may be used to link light receiver 312 on one side of circuit board 302 with light transmitter 315 on the other side of circuit board 302. Where it is desirable to increase the bandwidth of the circuit board's internal bus architecture, the

formed between light transmitter 430 on board 401 and light receiver 432 on board 402. Channel 461 is formed between light transmitter 435 on board 402 and light receiver 434 on board 403.

[0028] Backplane 406 in Figure 4 is fault-tolerant and self-healing. For example, if board 402 is removed from backplane 406, communication between light transmitter 410 and light receiver 414, between light transmitter 420 and light receiver 422, and between light transmitter 430 and light receiver 434 will be automatically reestablished at various times as board 402 is removed. For example, channels 460 and 461 will be the first to merge, followed by a brief merger of channels 440 and 441 as aperture 405 passes between light transmitter 410 and light receiver 414, followed by the reacquisition of channel 450, followed by a final merging of channels 440 and 441.

[0029] Each board can be programmed to automatically retry establishing an operable communication channel whenever a change in signal generation is detected. Alternatively, each board can be programmed to automatically reroute data traffic from an inoperable communication channel to an operable one whenever an absence of data signal (in one embodiment, light) is detected.

[0030] Contrast the self healing aspect of the present invention with the non-self-healing aspect of circuit boards using copper traces or optical fiber. In these types of boards, removal of the copper trace or optical fiber kills the channel, which remains dead as the faulty circuit board is removed, a new one inserted, the traces or optical fiber reconnected, and the system is reinitialized.

[0031] In one embodiment, boards 401, 402, 403 may each have the same or different functionalities. Similarly, expansion slots 407, 408, 409 may each have the same or different functionalities. For example, expansion slot 408 may have a specific signal the other expansion slots do not. In one embodiment, a board's functionality is "slot

independent”, meaning that the functionality resides entirely within the board. In another embodiment, each card’s functionality is determined by the expansion slot in which it is removably inserted (slot dependent functionality). In one slot dependent embodiment having eight expansion slots, two may be used as controllers, and the remaining six divided as needed between input/output and storage functions (e.g. four input/output and two storage).

[0032] Referring now to Figures 5a and 5b, Figure 5a shows a perspective view of a stack of eight circuit boards according to one aspect of the invention. Figure 5b illustrates a sectional end view of the stack of eight circuit boards shown in Figure 5a.

[0033] In Figure 5a, a stack of eight circuit boards is shown. The boards are consecutively numbered 1-8, with board 1 on the bottom of the stack, and board 8 on the top. One edge of each board includes one or more tabs that may be inserted into the expansion slot(s) of a backplane. The tabs are consecutively numbered 501-508 to correspond with the appropriate board. For example, board 1 includes tabs 501; board 2 includes tabs 502, board 3 includes tabs 503, and so on.

[0034] The tabs on each board occupy one or more of five columnar positions. In Figure 5b, the columnar positions are represented by columns 511, 512, 513, 514, and 515, which are numbered consecutively from left to right. The tabs are represented in Figure 5b as shaded rectangles. Each rectangle representing a tab is shaded the same as the board to which it is attached. For example, tabs 501 in Figure 5a are represented in Figure 5b as diagonally shaded rectangles because board 1 in Figure 5a is diagonally shaded. Additionally, the stack of boards in Figure 5b is numbered consecutively 1-8 on both sides, beginning with board 1 on the bottom and ending with board 8 on the top.

[0035] Careful arrangement of tabs 501-508 enables various pairs of boards located on different levels of the stack to communicate with each other. For example, tabs

affected communication channel, and (iii) to automatically reroute data traffic to another operable channel, and/or (iv) to automatically retry to establish communications in the affected channel(s).

[0039] Referring now to Figure 6, a sectional end view of a stack of eight tabbed circuit boards is shown according to another embodiment of the invention. The boards in the stack are consecutively numbered 1-8, beginning with board 1 on the bottom, and ending with board 8 on the top. In this embodiment, one edge of each circuit board has one or more tabs that may be inserted within the expansion slots of a backplane (not shown). The tabs are consecutively numbered 601-608 to correspond to the circuit board to which they are attached. For example, tab 601 is attached to board 1; tab 602 to board 2; tab 603 to board 3, and so on.

[0040] The tabbed portions of each circuit board may occupy one or more of three columnar positions 611, 612, 613. In Figure 6, these tabbed portions are represented by shaded rectangular blocks. For example, tabs 608 are represented by blocks filled with cross-hatched shading; tab 607 is represented by a block filled with uniform grey shading, and so on.

[0041] In Figure 6, tabs 601-608 are arranged within columns 601, 602, 603 to allow communications between pairs of boards located on different levels within the stack. For example, light transmitters 622 on the top surface of tab 601 can communicate with light receivers 624 on the bottom surface of tab 605. Similarly, light transmitters 623 on the bottom surface of tab 605 can communicate with light receivers 621 on the top surface of tab 601.

[0042] In this manner, a plurality of communication channels 610, 620, 630, 640, may be established between tabs 601 and 605. Similar pluralities of communication channels may be formed between tabs in columns 612 and 613. The two communication

channels 650 and 660 formed in column 613 may be used to relay a power signal from board to board. Additionally, the communication channels shown in Figure 6 are fault-tolerant and self-healing in the same way as the channels illustratively described with reference to Figure 5b.

[0043] Thus, apparatus and methods to communicate between a first circuit board and a second circuit board using one or more open air communications channels are disclosed. Although the present invention is described herein with reference to a specific preferred embodiment, many modifications and variations therein will readily occur to those with ordinary skill in the art. Accordingly, all such variations and modifications are included within the intended scope of the present invention as defined by the following claims.